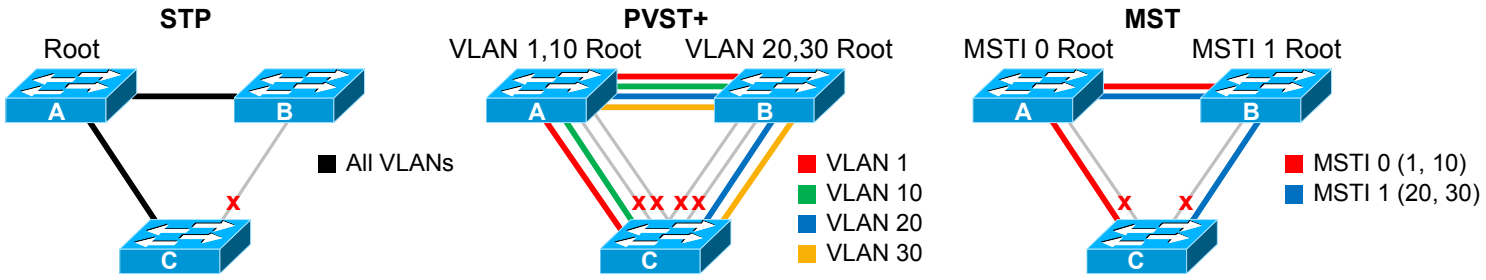
Spanning Tree · Part 1

Spanning Tree Protocols

	Legacy STP	PVST	PVST+	RSTP	RPVST+	MST
Algorithm	Legacy ST	Legacy ST	Legacy ST	Rapid ST	Rapid ST	Rapid ST
Defined By	802.1D-1998	Cisco	Cisco	802.1w, 802.1D-2004	Cisco	802.1s, 802.1Q-2003
Instances	1	Per VLAN	Per VLAN	1	Per VLAN	Configurable
Trunking	N/A	ISL	802.1Q, ISL	N/A	802.1Q, ISL	802.1Q, ISL

Spanning Tree Instance Comparison



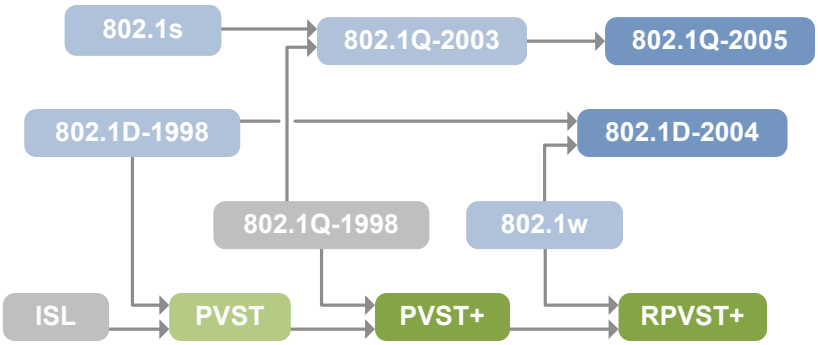
BPDU Format

Field	Bits
Protocol ID	16
Version	8
BPDU Type	8
Flags	8
Root ID	64
Root Path Cost	32
Bridge ID	64
Port ID	16
Message Age	16
Max Age	16
Hello Time	16
Forward Delay	16

Default Timers

Hello	2s
Forward Delay	15s
Max Age	20s

Spanning Tree Specifications



IEEE

- **IEEE 802.1D-1998** · Deprecated legacy STP standard
- **IEEE 802.1w** · Introduced RSTP
- **IEEE 802.1D-2004** · Replaced legacy STP with RSTP
- **IEEE 802.1s** · Introduced MST
- **IEEE 802.1Q-2003** · Added MST to 802.1Q
- **IEEE 802.1Q-2005** · Most recent 802.1Q revision

Cisco

- **PVST** · Per-VLAN implementation of legacy STP
- **PVST+** · Added 802.1Q trunking to PVST
- **RPVST+** · Per-VLAN implementation of RSTP

Spanning Tree Operation

1. **Determine root bridge**
   The bridge advertising the lowest bridge ID becomes the root bridge
2. **Select root port**
   Each bridge selects its primary port facing the root
3. **Select designated ports**
   One designated port is selected per segment
4. **Block ports with loops**
   All non-root and non-desginated ports are blocked

Link Costs

Bandwidth	Cost
4 Mbps	250
10 Mbps	100
16 Mbps	62
45 Mbps	39
100 Mbps	19
155 Mbps	14
622 Mbps	6
1 Gbps	4
10 Gbps	2
20+ Gbps	1

Port States

Legacy ST	Rapid ST
Disabled	Discarding
Blocking	
Listening	
Learning	Learning
Forwarding	Forwarding

Port Roles

Legacy ST	Rapid ST
Root	Root
Designated	Designated
Blocking	Alternate
	Backup

Spanning Tree · Part 2

PVST+ and RPVST+ Configuration

```
spanning-tree mode {pvst | rapid-pvst}

! Bridge priority
spanning-tree vlan 1-4094 priority 32768

! Timers, in seconds
spanning-tree vlan 1-4094 hello-time 2
spanning-tree vlan 1-4094 forward-time 15
spanning-tree vlan 1-4094 max-age 20

! PVST+ Enhancements
spanning-tree backbonefast
spanning-tree uplinkfast

! Interface attributes
interface FastEthernet0/1
 spanning-tree [vlan 1-4094] port-priority 128
 spanning-tree [vlan 1-4094] cost 19

 ! Manual link type specification
 spanning-tree link-type {point-to-point | shared}

 ! Enables PortFast if running PVST+, or
 ! designates an edge port under RPVST+
 spanning-tree portfast

 ! Spanning tree protection
 spanning-tree guard {loop | root | none}

 ! Per-interface toggling
 spanning-tree bpduguard enable
 spanning-tree bpdufilter enable
```

MST Configuration

```
spanning-tree mode mst

! MST Configuration
spanning-tree mst configuration
 name MyTree
 revision 1

 ! Map VLANs to instances
 instance 1 vlan 20, 30
 instance 2 vlan 40, 50

! Bridge priority (per instance)
spanning-tree mst 1 priority 32768

! Timers, in seconds
spanning-tree mst hello-time 2
spanning-tree mst forward-time 15
spanning-tree mst max-age 20

! Maximum hops for BPDUs
spanning-tree mst max-hops 20

! Interface attributes
interface FastEthernet0/1
 spanning-tree mst 1 port-priority 128
 spanning-tree mst 1 cost 19
```

Bridge ID Format

Priority
4-bit bridge priority (configurable from 0 to 61440 in increments of 4096)

System ID Extension
12-bit value taken from VLAN number (IEEE 802.1t)

MAC Address
48-bit unique identifier

Path Selection

1. Bridge with lowest root ID becomes the root
2. Prefer the neighbor with the lowest cost to root
3. Prefer the neighbor with the lowest bridge ID
4. Prefer the lowest sender port ID

Optional PVST+ Ehancements

PortFast
Enables immediate transition into the forwarding state (designates edge ports under MST)

UplinkFast
Enables switches to maintain backup paths to root

BackboneFast
Enables immediate expiration of the Max Age timer in the event of an indirect link failure

Spanning Tree Protection

Root Guard
Prevents a port from becoming the root port

BPDU Guard
Error-disables a port if a BPDU is received

Loop Guard
Prevents a blocked port from transitioning to listening after the Max Age timer has expired

BPDU Filter
Blocks BPDUs on an interface (disables STP)

RSTP Link Types

Point-to-Point
Connects to exactly one other bridge (full duplex)

Shared
Potentially connects to multiple bridges (half duplex)

Edge
Connects to a single host; designated by PortFast

Troubleshooting

```
show spanning-tree [summary | detail | root]
show spanning-tree [interface | vlan]
show spanning-tree mst […]
```